Job Loss Analysis

Control No: **Status:** Final **Original Date:** 6/1/11
Last Date Closed: 10/31/11

Organization:

SBU: Global Manufacturing
BU: All
Work Type: Technical (Process Engineering)
Work Activity: Compressor Performance Check for Process Engineers

Personal Protective Equipment (PPE)	Selected	Comments

Reviewers

Reviewers Name	Position	Date Approved
Michelle Johansen	Process Engineering Manager /Global JLA Development Team Leader	10/31/11
Ken Wohlgeschaffen	Sr Hydroprocessing Engineer	8/11
Jimmy Lam	Sr Process Engineer	8/11
Mike McKee	FCC BIN Leader	8/11

Development Team

Development Team

Development Team Member Name	Primary Contact	Position
Olivia Campos	Yes	Process Engineer

Job Steps

No	Job Steps	Potential Hazard	Critical Actions
Process Condition Checks			
1	Ensure that gas gravity is not too high.	1. Speed control/ rack valve goes wide open and gas rate starts to oscillate; premature surge. 2. Condenser vacuum becomes difficult to maintain 3. Off-test product and equipment fouling	1a. Increase bleeds/wash water rates/ DEA rates to remove heavy contaminants. 1b. Reduce unit feed rates if necessary. 2. Consult RER/IMI to determine if turning on hogging jets will help

			regain vacuum. Ensure good cooling water flow. 3a. Reduce system temperatures (e.g. reactor temperatures or high pressure separator temperatures for Hydroprocessing units) where possible to separate/condense out heavy contaminants – this may mean lowering furnace firing, increasing cooling water rates or commissioning fin-fans. 3b. If fresh material is lighter (e.g. manufactured hydrogen for Hydroprocessing recycle loops), introduce fresh material to the system to restore gravity.
2	Ensure that gas gravity is not too low.	1. Additional speed required to achieve the same flow rate, or flow rate begins to drop with compressor at max speed; premature choke.	1a. Decrease bleeds/wash water rates/ DEA rates to introduce impurities of higher gravity. 1b. Increase system temperatures where possible to vaporize heavier materials. 1c. If fresh material is heavier (e.g. makeup hydrogen from a low purity source for Hydroprocessing recycle loops), introduce fresh material to the system to restore gravity.
3	Ensure suction pressure is not too low.	1. Low differential head across compressor, low gas flow, low efficiency higher energy consumption, and premature choke.	1a. Increase system pressures where possible, while avoiding increased temperatures. 1b. Look upstream of compressor to search for sources of high dP. Complete a pressure survey. See if any equipment can easily be cleaned, washed or relieved of hydraulic constraints
4	Ensure suction pressure is not too high.	1. Premature surge.	1. Decrease system pressures and throttle valves where possible.
5	Ensure suction temperature is not too high.	1. Low differential head across compressor, low gas flow, low efficiency higher energy consumption, and premature choke.	1. Decrease system temperatures where possible while avoiding decreased pressures.
6	Ensure suction temperature is not too low.	1. Premature surge.	1. Increase system temperatures where possible.
7	Ensure good cooling water flow.	1. Loss of surface condenser vacuum.	1a. Check cooling water supply pressure 1b. Backwash the exchanger 1c. Check hotwell temperature.
8	Ensure that there are no leaks around the turbine and surface condenser.	1. Loss of surface condenser vacuum.	1a. Check sealing steam pressure to ensure no turbine seal leak. 1b. Check water flow to PRD vent pipe to ensure no PRD leaking. 1c. Switch condensate pumps and isolate to address condensate pump seal leak. 1d. Check all flanges, bull plugs and piping for air leaks. 1e. Consult with SME – possibly experienced Operator, BIN Leader,

			I&E Engineer, etc.
9	Identify excess frictional losses	1. Low differential head across compressor, low gas flow, low efficiency and higher energy consumption.	1a. Check for high lube oil temperature rise to identify high bearing and seal frictional losses.
10	Ensure the integrity of the discharge check valve.	1. Blocked gas flow/ low gas flow.	1. Survey the pressure upstream and downstream of the valve to check for high pressure drop and possible mechanical issues/plugging.
11	Audit the compressor's instrumentation and sampling capability.	1. Incorrect flow measurements 2. Incorrect online gas analysis 3. If compressor discharge pressure indication is downstream of a process device or restriction (e.g. check valve), compressor performance can be incorrectly interpreted as poor -- low differential head and compressor efficiency. 4. Non-representative samples	1a. Ensure all meters are calibrated and corrected for temperature, pressure and gravity. 1b. Ensure measurements are consistent. Confirm with a mass balance if possible. Check that multiple process indications support what you are seeing. 2. Ensure all online gas analyzers are calibrated regularly and match with sample analyses. 3. Ensure all instrumentation is upstream of any process device, such as a valve or diversion/recycle piping. 4. Ensure sample station is in proper location – downstream of all gas tie-ins or bleeds leading to the compressor suction.
12	Monitor the efficiency of the compressor and driver versus curve	1. Higher energy consumption and compressor operation off of curve due to internal energy losses. 2. Higher energy consumption and compressor operation on curve but away from best efficiency point.	1. Complete Compressor Performance Check for Process Engineers JLA to specifically identify and address the process condition or mechanical damage/fouling causing operation off of compressor curve. 2. Adjust flow through compressor to operate nearer to best efficiency point. Through manipulation of a spillback, this can be done without affecting other process conditions throughout the system.
13	Identify events that may have contributed to a change in compressor performance/operation.	1. Inefficient identification of process issue that is leading to poor performance/operation	1a. Identify when the event/problem occurred/began and what else changed/was different at that time. 1b. Develop a brainstorm list of possible causes, then systematically rule them out by checking each against evidence for and evidence against.
Design Considerations			
14	Ensure no tight elbows with high velocity flow directly upstream of the compressor suction. This usually leads to non-uniform flow upstream of the compressor suction and flow meter.	1. Poor performance, including: low head; running near surge in one section of the compressor while operating near the overload region in another section; low capacity; low efficiency; low power.	1. Consider addition of a flow equalizer in the line for the next shutdown/ turnaround. 2. Consider the removal of tight elbows with high velocity flow directly upstream of the compressor

		2. Inaccurate flow data.	suction.
15	Ensure there aren't multiple elbows on different planes upstream of the compressor suction. This usually leads to swirl or vortex flow upstream of the compressor suction and flow meter.	1. Poor performance, including: low head; low capacity; low efficiency; low power; premature choke. 2. Inaccurate flow data.	1. Consider addition of a flow straightener in the line for the next shutdown/ turnaround (egg crate or guide vanes). 2. Consider piping modifications to remove multiple elbows on different planes upstream of the compressor suction.
Compressor Performance Test – Identify Operation Relative to Curve			
16	If process conditions are okay and match design, consult RER to coordinate a compressor performance test to identify fouling, internal recirculation, or other mechanical damage. Ensure use of accurate data for a compressor performance test.	1. Inaccurate gas analysis, which can skew the results of the performance test; for a high pressure, high molecular weight gas taken at high temperatures, the heavy gas may condense on the walls when it cools. 2. Erroneous performance test results due to liquid carryover to the compressor. 3. Erroneous pressure data due to liquids in pressure tap lines.	1a. Take gas samples at both the suction and discharge points. Check for condensibles and compensate by heating the sample before analyzing. 1b. Consult with RER or compressor experts to ensure Good and Best Practices are being followed for gas sampling, as this is critical for a good performance test. 2. Measure the flow rate at each flange. Liquids in the gas stream will give erroneous flow indication. A simple mass balance is a good check for both flow instrumentation accuracy and possible liquids in the gas. 3. Open drain valves and low spots in process piping and instrumentation before, during and after a test.
Fouling – Address Fouling Contributors to Operation Off Curve			
17	Ensure no dirt, polymer buildup, salts or other solids clogging the gas passages.	1. Low differential head across compressor, low gas flow, low efficiency higher energy consumption, and premature choke.	1a. Check the process gas for any contaminants applicable to the process – work with technology SME to identify potential contaminants and methods of detection, and work with upstream units to understand quality of gas supplies. 1b. For larger compressors, consider cleaning the compressor during normal operation with organic abrasives like uncooked rice or walnut shells. Work with Operations and RER.
18	Ensure no dirt and buildup between impellers and diaphragm.	1. High vibration	1a. Consider a liquid wash while the unit is offline. 1b. Consider a continuous online flush with a max solvent injection of 3% of compressor mass flow rate to help prevent buildup. Work with Operations/RER/Maintenance. 1c. Coat diaphragm (backplate) surfaces with an anti-stick compound for fouling resistance. Work with RER/Maintenance.

Inspection Opportunities – Address Mechanical Contributors to Operation Off Curve ***General Knowledge – Many of these checks may be completed by RER/Maintenance**			
19	Ensure no internal recirculation.	1. Low head; low capacity; high power; low efficiency; premature choke.	1a. Upon equipment inspection, check for damaged balance piston seal. 1b. Upon equipment inspection, check for damaged inter-stage seals. 1c. Upon equipment inspection, check for signs of recirculation across the diaphragm splitline (streak marks). For a horizontal split compressor, check that the diaphragm is not locked in place as the top-half casing is lifted. If the diaphragm is locked in place, remove and clean. 1d. Upon inspection, check the splitline for dirt, tools, etc.
20	Other inspection opportunities.	1. General troubleshooting	1a. Check for proper rotation of impeller and return channel vanes. 1b. Check for large blockages in the flow passages, such as hardware. 1c. Check for erosion at the impeller blades and diffuser passages. 1d. Check that the balance line sleeve or O-ring is in place if applicable. 1e. Record shaft, impeller eye, or blade tip, and balance piston seal clearances and check against operating manual. 1f. For axial compressors, check blade clearance to stationary hardware against factory specs. Increase in clearance can significantly reduce efficiency. 1g. Pull flow meters and check orifices. Also check for debris or buildup directly upstream and downstream of the meter. Bad flow indication can lead to false performance data. 1h. Inspect pressure taps.

Recycle Comments

Quality Reviews

Field Verification & Validation